Fw: CWIS Meeting Follow-up
Brian Mueller to: Mark Stead, Laura Hunt 10/22/2009 11:19 AM
Cc: Charlie Howell, Willie Lane, Js Wilson, Isaac Chen, Jamie Hurley, Curry Jones

For your review and comment . I just spoke with Mr. Little and they are wanting a reply back from us by the end of next week.

thanks

bwm
----- Forwarded by Brian Mueller/R6/USEPA/US on 10/22/2009 11:15 AM -----

From:	steve.e.little@exxonmobil.com
To:	Brian Mueller/R6/USEPA/US@EPA
Cc:	"Gary Northington" <gnorthington@chevron.com>, joe.p.smith@exxonmobil.com, ian.voparil@shell.com
Date:	10/22/2009 10:40 AM
Subject:	CWIS Meeting Follow-up

As follow-up to our meeting on 10/14/09, OOC provides the following attached memorandum from LGL Ecological Research Associates, Inc. regarding the following 4 issues.

Sampling upstream vs. downstream of the study sites
SEAMAP spatial variability with regard to the number of sample sites
Reducing monthly sampling intensity and sampling more sites
Evaluating the study data against SEAMAP data to determine if SEAMAP data is adequate for future impact assessments

Note- A summary discussion for Item 4 is provided in the memorandum however a detailed discussion is contained in Section 2.4 of the CSA International Inc. study proposal. A file containing this Section is attached for your convenience should you require the additional detail.

Feel free to contact Joe Smith or me if there are additional questions.
(See attached file: LGL Memorandum 10-09.pdf)(See attached file: LGL Memo Figs. 1 & 2 10-09.pdf)(See attached file: CSA Proposal Section 2.4.pdf)

Steve Little
ExxonMobil Production Company
U.S. Production
Regulatory Compliance Group

Phone 281-654-1015 Fax 281-654-1147

LGL Memorandum 10-09.pdf LGL Memo Figs. 1 & 2 10-09.pdf
CSA Proposal Section 2.4.pdf

LGL
Ecological Research Associates, Inc. 1410 Cavitt Street, Bryan, Texas 77801 (979) 775-2000
FAX (979) 775-2002

MEMORANDUM

FROM: Benny J. Gallaway, Ph.D.
LGL Ecological Research Associates, Inc.
1410 Cavitt Avenue
Bryan, TX 77801

DATE: 22 October 2009

TO: Joseph P. Smith
Chairman, Cooling Water Intake Structure Steering Group
ExxonMobil Upstream Research Company (URC-URC-S306)
P.O. Box 2189
Houston, TX 77252-2189

RE: SEAMAP Comparisons

I have read your notes of a meeting with EPA on October 14, 2009 to discuss plans for the proposed entrainment monitoring study. I have also reviewed the PowerPoint presentation and other materials that were given and discussed at the meeting. The primary issues that need to be addressed include 1) sampling upstream versus downstream of the intake, 2) spatial variability as it relates to the number of sites that need to be sampled, 3) sampling evenly among months versus reducing the number of months sampled and sampling more sites, and 4) what criteria are we using to decide if the SEAMAP data are suitable for future assessments.

1) Sampling Upstream vs. Downstream of Study Sites

While, as was done at the meeting, a case can be made for both approaches, it would be conceptually best to sample upstream of the intake. Samples from this area would best approximate the egg and larval densities passing by the intake. Ichthyoplankton produced at the platform would be carried away from the intake rather quickly and would not likely be subject to appreciable impact.

2) SEAMAP Spatial Variability re Sampling Sites

Gallaway et al. (2004)'s analysis of SEAMAP data found that East-West planktonic densities and composition are remarkably homogeneous along isobaths throughout the Gulf of Mexico. As a result, the three proposed sites likely represent conditions over a large area of the Gulf, and this assumption will be validated when site data is calibrated with the SEAMAP dataset (*see response to Topic 4*). Using the divisions developed for the Offshore Operators Cooling Water Intake Structure Source Water Biological Baseline Study, the three proposed sampling sites are in the biogeographic zones C4 (east of and near the Mississippi River influence), C5, and W5. Sites C5 and W5 provide information on the deepwater Gulf with water depth > 1000 m, and C4 provides information on the continental slope where water depth varies from 200-1000 m.

As provided in the October 14 PowerPoint presentation, 3 sampling sites equals (and likely exceeds) the number of new regulated CWIS in operation or in the planning process for commissioning by year end 2014. The Baseline Study for CWIS in the Gulf suggested that future developments would essentially be restricted to biogeographic zones C4 and C5 and W4 and W5 (see "Offshore Operators Cooling Water Intake Structure Source Water Biological Baseline Study" approved by the EPA 05 October 2009). Most of the projected new developments will occur in biogeographic zones C4 and C5 with less development expected to occur in zones W4 and W5.

Gallaway et al. (2004) conducted an analysis of alongshore variability of SEAMAP ichthyoplankton density in the central and western Gulf of Mexico. They analyzed SEAMAP density data for 100 equal-sized, overlapping polygons arrayed east-to-west at similar depths. The polygons covered a total distance of about 400 km. A total of 42 of the 100 polygons were considered to be under the influence of Mississippi River discharge (eastern polygons); 58 were sited to the west of the area influenced by river discharge (western polygons).

Eggs and larvae in polygons near the mouth of the Mississippi were more abundant than in polygons west of the river mouth. This finding was consistent with expectations. Within each of the eastern and western polygon sets, however, ichthyoplankton densities and species composition were remarkably constant. For example, 121 of the 158 larval taxa found in all 52 western polygons (77%) occurred in the single polygon that was of the primary interest of the study. The species composition and relative abundance for the 58 western polygons considered as a group was also highly similar to that observed at the primary study site of interest. Gallaway et al. (2004) concluded that there was remarkable consistency in larval fish densities and species composition along similar isobaths. They suggested that once an assessment had been conducted for a site within a biological grid, additional sites for the same grid could be evaluated based upon the initial assessment. The Minerals Management Service has successfully used such a "tiered" approach for deepwater oil and gas developments.

3) Reducing Monthly Sampling Intensity and Sampling More Sites

As described above, we believe three sites represent an adequate sample for making the impact assessments based upon monitoring study data. We believe there is considerably more uncertainty about the seasonal patterns of ichthyoplankton abundance than there is uncertainty about spatial patterns of abundance in deep water. The PowerPoint presentation given 14 October 2009 showed the low number of existing samples in each zone for each month, and described how monthly sample size would be increased with the monitoring study.

Also, as shown by Figures 1 and 2, there were no clear patterns of seasonal abundance of eggs and larvae in zones C4 and C5 or zones W4 and W5. On a monthly basis the data are sparse and the variation is high. We think the monitoring study should first focus on defining monthly and seasonal patterns of abundance and species composition. We believe it would be inadvisable to reduce monthly sampling intensity until we are better able to define seasonal patterns of abundance. Seasonal patterns are expected to be more variable than spatial abundance differences across the similar depth zones where development is expected to occur.

4) Evaluating SEAMAP Data

The question was raised regarding how we would go about determining if the SEAMAP data might be adequate for making the required impact assessments. To address this question, we extract the following summary of our statistical approach from our proposal.

The new CWIS operations will entrain a quantity of larval fish and eggs. The magnitude and species make-up of these losses may differ from site to site. Of interest will be knowing whether SEAMAP data can accurately estimate these losses so that future sampling specific to each CWIS operation will not be necessary. Thus, we will compare population densities and community indices across three spatial resolutions: 1) SEAMAP regional data — the SEAMAP data stratified into broad biogeographical regions; 2) SEAMAP proximate data — the SEAMAP data that fall within a specified polygon around the proposed CWIS operation; and 3) site-specific data — samples collected at the actual CWIS operation site during the course of the proposed study. At the lowest ecological scale will be individual species densities, which can be compared on a univariate basis for select species of concern to address population level differences. Multivariate testing of the proportional abundances of all species (PA = abundance of a species in the sample/total abundance across all species in the sample) addresses differences in assemblage structure. Another way of testing community level differences is to compare overall species richness (number of species present) and species evenness (how equally dispersed individuals are across species), both of which are univariate metrics.

A more detailed discussion of the proposed statistical analysis can be found in Section 2.4 of our proposal.

Reference

Gallaway, B.J., J.G. Cole, and R.G. Fechhelm. 2004. Revisions to an assessment of potential ichthyoplankton losses from impingement and entrainment associated with offshore LNG facilities in the western Gulf of Mexico. Addendum for ExxonMobil Development Company, Houston, TX 44p + Append.

Benny J. Gallaway
(by Jean Erwin)

Benny J. Gallaway, Ph.D.
PRESIDENT

BJG/je

cc: Ian Voparil
Steve Little

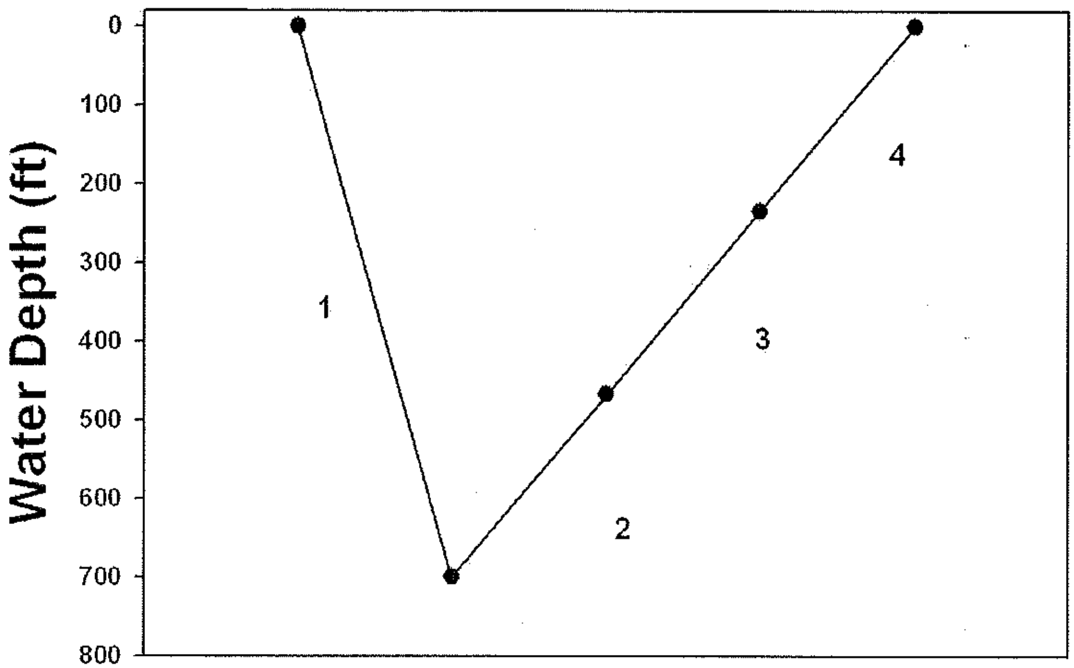


Figure 3. Diagram of proposed stepped-oblique towing pattern. Numbers (1 to 4) indicate net.

2.4 DATA ANALYSIS AND ASSESSMENT

We have proposed a thorough statistical treatment of the collected ichthyoplankton data with extensive integrations with existing SEAMAP data and impact assessment modeling in order to meet the objectives of the project and ensure that the results of the study are acceptable to the EPA. This effort also includes the data management and GIS needed to conduct the project. In the event that the CWIS Steering Group believes that this effort is excessive, we will gladly discuss the level of effort envisioned by the Steering Group.

This study will generate depth-resolved, site-specific density data (n/m^3) for fish eggs, fish larvae, and early life stages of commercially-important invertebrates. The latter two categories will be identified to life stage and the lowest practical taxa. Data will be obtained using MOCNESS nets that have the same opening and mesh size as the SEAMAP bongo nets. The depth-resolved data will be used to evaluate the potential mitigation benefits that might be realized by locating the intake structures at various depths. The site-specific data gathered in this project will be used to estimate potential impacts of entrainment based on two factors: 1) absolute levels of entrainment and 2) assessment models (Equivalent Adult Models [EAMs] and Fecundity Hindcasting Models [FHMs]) as described by Gallaway et al. (2007) and used in the OOC baseline characterization study. While the OOC baseline characterization study identifies available life history data from the scientific literature, we now realize that an important source of life stage and larval mortality data for some important species (e.g., dolphinfish) may be found in the marine aquaculture literature that was not reviewed. Our team will review this source of information for additional life history information.

With appropriate life history data, it is possible to place entrainment losses into the context of ecological significance by showing the expected number of adults that might be lost or, conversely, the amount of eggs that are best expressed in the context of how many adult females would be required to produce that number of eggs. Our plan for addressing the significance of the estimated fish egg, larvae, and important invertebrate entrainment losses for species with life history data that are not available is to utilize the Gallaway et al. (2007) approach based on proportional water use. In this approach, entrainment losses are compared with the population within a larger reference parcel of water, which will be one half the volume encompassed by a cylinder of water with a radius equivalent to 1 day's transport of the intake and at a depth equivalent to the water depth at the facility or somewhere below the depth of the intake. The ichthyoplankton population in one half the volume of this parcel will be estimated by multiplying the volume by the same density estimates used in the entrainment analysis. For the facility evaluated following this approach by Gallaway et al. (2007), the estimated eggs and larvae removed on a daily basis was on the order of 0.015% of the population passing by the site each day.

2.4.1 Representative Key Species Selection

Key species will be determined based on their value to man and their role and value to the ecosystem. The first step in our analysis will be to rank the species present in the vicinity of each site in order of abundance and classify them in terms of their commercial or recreational value to man and/or their ecosystem value or trophic role (e.g., forage species, small benthic predator, pelagic predator, etc.). Using this information, we will propose a list of key species for detailed analyses subject to approval by the OOC and the EPA. From the baseline study, we already know that red snapper, some groupers, tuna fishes, and dolphinfish should be on this list. In further review of the species composition data by geographic region, we also know that billfishes and a number of clupeid species will be added to this list. We will review the selection of key representative species during the first year review and make appropriate modifications to focus on representative species.

2.4.2 Initial Data and Preliminary Data Analyses

Data gathered in this monitoring project will be recorded either by using the same data formats and analysis approaches used in the SEAMAP program or by developing analysis programs to convert our data formats to the same format used by SEAMAP, whichever is more efficient. In the SEAMAP studies, catches from bongo nets are standardized to account for sampling effort (i.e., volume filtered) and then expressed as the number of larvae under 10 m^2 of sea surface (Lyczkowski-Shultz et al., 2004). This is accomplished by dividing the number of larvae of each taxon caught in a sample by the volume of water filtered during the tow, then multiplying the resultant by the maximum depth of the tow (in meters) and the factor 10. For our purposes, the density estimate (number/m^3) is the value of interest.

Initial processing of SEAMAP plankton samples is carried out at the Sea Fisheries Institute, Plankton Sorting and Identification Center (ZSIOP) in Szczecin, Poland and the Louisiana Department of Wildlife and Fisheries (LDWF) (Lyczkowski-Shultz et al., 2004). Vials of eggs and identified larvae, plankton displacement volumes, total egg counts, and counts and length measurements of identified larvae are sent to the SEAMAP Archive at the Florida Marine Research Institute in St. Petersburg, Florida. These data are entered into the SEAMAP database, and specimens are curated and loaned to interested scientists. Data files containing specimen identifications and lengths are sent to the NMFS Mississippi laboratories, where these data are combined with field collection data and edited according to established SEAMAP editing routines. SEAMAP survey data are currently maintained in dBase file structures, but conversion to an Oracle-based system is underway.

There are two important points to note concerning the use of SEAMAP data. First, a standard U.S. Coast Guard/Maritime Administration (USCG/MARAD) protocol in assessments of LNG facilities in the Gulf of Mexico is to multiply all reported ichthyoplankton densities by a factor of three to account for the extrusion of the smallest larvae though the mesh net (USCG and MARAD 2003, 2004, 2005a,b, 2006a,b); this protocol was adopted to cover the larvae of all species of fish, and this study will adhere to that precedent. All larval densities obtained from the SEAMAP database will be multiplied by a factor of three prior to any detailed analysis. Second, SEAMAP data are for the eggs and larvae of fish only and do not include data for invertebrates.

A detailed description of methods for preparing the SEAMAP ichthyoplankton data (and the data gathered in this project) for assessment analysis is provided in **Appendix B**. These descriptions identify the three SEAMAP datasets (i.e., STATCARD, ICHSTRWK, and ICHSARWK) that are used in conjunction with one another to estimate fish larvae and egg densities as well as the relevant fields within each dataset. The SEAMAP database is continually being updated (i.e., adding the next year's results, receipt of new laboratory analysis results from ZSIOP and LDWF, corrections of errors, etc.). Because the SEAMAP files are subject to updating, we believe it is a best practice for any analysis we do based on this data to state the name and provenance of the data file that was used.

The STATCARD dataset describes when and where sampling operations took place. The ICHSTRWK dataset contains gear code information, volumes filtered, and all of the egg data, whereas the ICHSARWK dataset provides data about individual taxa, including size information. As described in **Appendix B**, STATCARD and ICHSTRWK can be merged based on three fields (i.e., cruise number, vessel, and Pascagoula Station Number). The sample number field is required to merge these data with the ICHSARWK dataset.

2.4.3 Assessments Based on Site-Specific Tows

The new data collected at each of the three monitoring sites using SEAMAP methods will be used to estimate entrainment impacts at the individual sites based on the mean densities over all depths combined, providing a mean density similar to the depth-integrated sampling used by SEAMAP. These SEAMAP-type samples will be used in the site-specific assessment. The results of this assessment will be compared to results of assessments using the historical SEAMAP data for a polygon around each site and at a geographic zone level of resolution, as described below.

2.4.4 Assessment Based on SEAMAP Proximate Tows and USGS/MARAD Polygons

An assessment for each site also will be conducted using historical SEAMAP data and the USCG/MARAD polygon approach. Descriptions of this analysis can be found in **Appendix** B under the section "Analysis Constraints," which, in this case, describes a rectangular polygon drawn around a proposed LNG site. Samples from within the rectangle were taken to be representative of the ichthyoplankton densities that might be encountered at the site; data from stations outside the rectangle were eliminated from the analysis. This polygon approach has been used in all the LNG sites proposed for the Gulf of Mexico. We also will use this approach for analyzing the historical SEAMAP data at each of the three monitoring sites included in this study. The rectangular polygon will consist of three 30-min blocks, one centered on the project facility and one block both east and west of the proposed site.

2.4.5 Assessment Based on SEAMAP Regional Tows and Geographic Regions

A project monitoring site is located in each of the three geographic zones (zones C4, C5, and W5), as identified in the OOC baseline characterization study. We propose to use the historical SEAMAP density data for these polygons as another basis for impact assessment and compare the impact estimates to those obtained using the polygon and site-specific approaches. If the assessments yield similar results, one interpretation might be that site-specific sampling at the resolution required by the monitoring plan is not warranted (i.e., approximately 30 years of SEAMAP data for an area or region comprise an adequate basis for assessment).

2.4.6 Mitigative Effects of Intake Depth

The depth-resolved samples will be used to evaluate the mitigative effects of locating the intakes at different depths to avoid high-density ichthyoplankton zones. The analyses will be patterned after those described in **Section 2.3.8**. Here, the focus will be on comparing entrainment impacts for intakes located at different depths at each monitoring site considering time of day, month, and year.

2.4.7 Statistical Methods for Comparing SEAMAP Data to Site-Specific Data

Before proceeding, we will present a summary of our approach. The new CWIS operations will entrain a quantity of larval fish and eggs. The magnitude and species make-up of these losses may differ from site to site. Knowing whether SEAMAP data can accurately estimate these losses so that future sampling specific to each CWIS operation will not be necessary is a topic of interest regarding this study. Thus, we will compare population densities and community indices across three spatial resolutions: 1) SEAMAP regional data —SEAMAP data stratified into broad bio-geographical regions; 2) SEAMAP proximate data —SEAMAP data that fall within a specified polygon around the proposed CWIS operation; and 3) site-specific data — samples collected at the actual CWIS operation site during the course of the proposed study. Individual species densities will be at the lowest ecological scale, which can be compared on a univariate basis for select species of concern in order to address population level differences. Multivariate testing of the proportional abundances of all species (PA = species abundance in the sample/total abundance across all species in the sample) addresses differences in assemblage structure. Another way of testing community level differences is to compare overall species richness (number of species present) to species evenness (how equally dispersed individuals are across species), both of which are univariate metrics.

As described below, we will use negative binomial or Poisson regression, depending on goodness-of-fit, to test for differences across the spatial resolutions with respect to individual species densities and species richness. If the best model includes the categorical term for whether a tow was from the site-specific sampling or SEAMAP sampling, we will judge the SEAMAP data to be too coarse for estimating the effects of entrainment loss on the biological system. In other words, it will mean that there were enough differences to justify stratifying the data according to the spatial resolution from which it was collected, and, therefore, the SEAMAP data and the site-specific data were incongruous. Adding physiochemical covariances may help explain these differences and rehabilitate the SEAMAP data (i.e., taking covariates into account may explain the site differences, enabling the use of SEAMAP rather than site-specific data). We will use Monte Carlo randomizations to test for differences across the spatial resolutions with respect to species evenness. Assemblage structure will be compared with a multiple response permutation procedure (MRPP). Significant differences in either evenness or assemblage structure would indicate that distributions of individuals across species were dissimilar among the spatial resolutions. If differences are found in any of the above metrics, canonical correspondence analysis will be used to identify which environmental covariates are controlling these differences.

Independent Variables

Three categorical spatial resolutions will be designated from the two datasets. The SEAMAP data (first dataset) can be divided into bio-geographical regions that will represent the coarsest spatial resolution, which will be termed "SEAMAP Regional Tows" (SRT). SEAMAP tows closer to the study sites may be more representative of site-specific community structure and localized population densities; therefore, we will create a rectangular polygon on each site and designate all SEAMAP tows within this polygon as belonging to the resolution "SEAMAP Proximate Tows" (SPT). Finally, the dataset generated from the proposed entrainment study (second dataset) will represent the finest resolution, termed "Site-Specific Tows" (SST). Again, our objective will be to determine whether the SEAMAP data can be used to accurately quantify the level of entrainment by the proposed LNG operations and the resulting ecological impact. Each tow sample will be designated as belonging to at least one of the three spatial resolutions described above; all tows will belong to an SRT region, a subset of SEAMAP tows within each SRT region will belong to various SPTs, and only tows sampled for the proposed entrainment study will belong to each SST. The more homogenous the tow samples are across spatial resolutions with respect to community diversity metrics and individual species densities, the less important the categorical variable SST will be; this finding will mean that the SEAMAP data can be used to quantify entrainment.

Fish egg and larval densities will change throughout the year as a function of spawning intensity and may vary from year to year for a given species due to varying year class strengths controlling the number of spawners. Thus, temporal stratification will include the categorical variables year, season, and month. Spatial and temporal stratification will help to homogenize species shifts throughout the Gulf. If the term SST is determined to be important (i.e., the SEAMAP data cannot be used to accurately portray entrainment loss), then adding covariates to the model may help to explain what is causing the localized differences. These variables include maximum water depth, temperature, salinity, dissolved oxygen, turbidity, and water density. If the variable data explain enough variation, then the SST term may no longer be warranted and the SEAMAP data in concert with the important covariates may be enough to estimate entrainment loss.

Dependent Variables

Both univariate and multivariate responses will be available in the resulting datasets. The densities of select species will each represent a univariate distribution with certain characteristics. The raw counts of individuals will be Poisson distributed and may be overdispersed with numerous zeros. In addition, the effort that produced each sample (i.e., the volume of water filtered) will vary and must be accounted for in the analyses. Often, researchers will divide the count of individuals by the corresponding effort for a given sample to render counts per cubic meter. Though this metric appears to be on the continuous scale because decimal values are present, this designation is artificial and the data should not be treated as such (Power and Moser, 1999). Varying effort is more appropriately incorporated as an offset (termed varying element size by Power and Moser [1999]) to the λ parameter that defines the Poisson distribution from which the data were produced. If the data were generated from a compounded Poisson (i.e., from several Poisson distributions unbeknownst to the sampler), then overdispersion will occur, as is often the case with plankton data. The negative binomial is a discreet probability distribution recognized as a suitable descriptor of net catch count data (Power and Moser, 1999).

Species diversity can be separated into two components, richness (the number of species) and evenness (Pielou, 1977). Most, if not all, diversity indices combine them in various ways to yield confounded results (Washington, 1984). It is not possible to tell whether one site yields a higher diversity index (e.g., the Shannon-Wiener Index) relative to another because its individuals are more evenly distributed across species or because it possesses more species. Therefore, we will analyze species richness and evenness separately as univariate metrics.

Another way of testing community level effects besides richness and evenness is to index assemblage structure. Species abundances in each sample will be converted to proportional abundances (i.e., abundance of a species in the sample/total abundance across all species in the sample). Proportional abundances represent a multivariate index that can be compared across categorical variables to assess whether subtle changes in the fish community are occurring.

Model Selection and Statistical Testing

We will portray the predicted catch rates of select individual species through a global linear log link function to the negative binomial distribution. All computations will be conducted using the GENMOD procedure in SAS version 9.1.3 software (SAS Institute Inc., 2003). The GENMOD procedure estimates the regression parameters to maximize the negative binomial log-likelihood. In addition to the global model (the model containing all independent variables), all nested combinations of variables will be compared using the information-theoretic approach as recommended by Burnham and Anderson (2002). Weights will be assigned to each model based on their Akaike Information Criterion (AIC) values, which will be modified to QAIC values by dividing the log-likelihood for each model by the variance inflation factor from the global model as recommended by Burnham and Anderson (2002) to account for overdispersion. Of the suite of models investigated, Akaike weights sum to one and indicate how probable one model is compared to all others considered. If the models receiving the most weight include a term for SST, then the data suggest that the SEAMAP sampling program is too coarse for quantifying entrainment and that site-specific sampling is needed for each LNG operation.

In the past, researchers have typically compared species richness among communities with rarefaction analysis (Sanders, 1968), and Monte Carlo simulations are then used to distinguish real differences from random fluctuation. Recently, some ecologists (e.g., McNally et al., 2003) have recognized that species richness also will be Poisson distributed and subject to the same statistical approaches described above for individual species densities. This latter approach allows covariates to be more readily incorporated while testing among categorical variables.

We will use the evenness index proposed by Smith and Wilson (1996), which is based on the variance (an innate measure of evenness) of species abundances within each sample and ranges from 0 (minimum evenness) to 1 (maximum evenness). Smith and Wilson (1996) found that this index was independent of species richness and provided the best measure of evenness. Differences in evenness among categorical variables will be determined from Monte Carlo randomizations. For each comparison, species abundances will be randomized 1,000 times between the two sites, and the evenness values will be calculated. The difference in observed evenness between the sites will be compared to the 1,000 differences from the randomized data to obtain the probability (P value) that a difference equal to or greater than the observed difference could have occurred by chance.

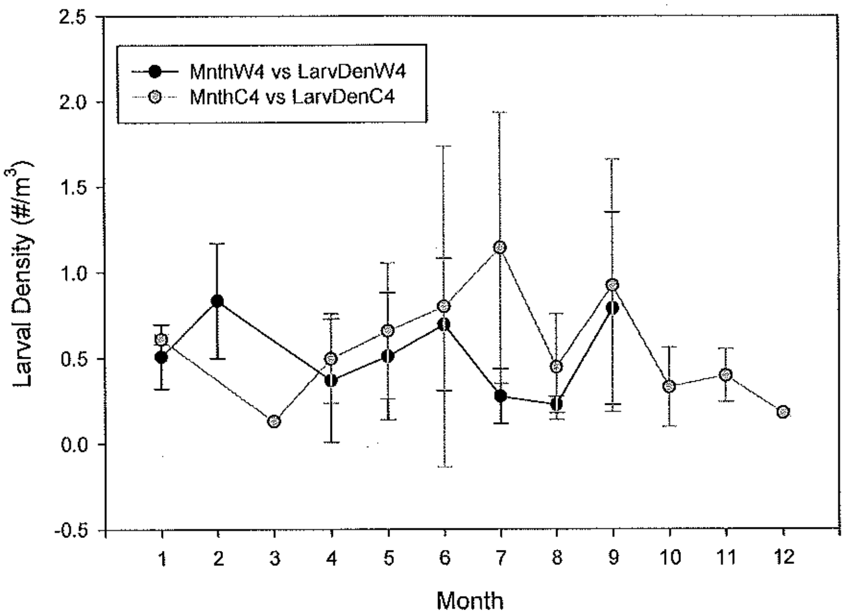
For the multivariate analysis of assemblage structure, we will first test to see if assemblage structure differs across categorical variables and then test whether any of the available covariates can explain these differences. We will use the MRPP to test for differences among categorical variables with respect to assemblage structure. This analysis is a non-parametric procedure that does not require the assumptions of multivariate normality and homogeneity of variances (Zimmerman et al., 1985; Biondini et al., 1988). The MRPP algorithm computes a matrix of Euclidean distances among samples and estimates the probability (P value) of randomly getting within-group distances as small as or smaller than the within-group distances observed. The smaller the average distance among samples within each group, the more alike samples were within groups. The MRPP also outputs an agreement statistic (A); values of A range from 1 (all samples within each group are identical) to zero (within-group distances are equal to distances expected by chance) to less than zero (within-group distances are greater than expected by chance). An A >0.3 is fairly high (indicating differences in assemblage structure), and it is not uncommon for A to be less than 0.1 and still be statistically significant (McCune and Mefford, 1999).

Canonical correspondence analysis (CCA), a form of direct gradient analysis (ter Braak and Prentice, 1988), will be used to examine how sites and species are related to covariates and to test if assemblage structure was significantly correlated with these covariates. During this technique, the ordination of samples and species is constrained by their relationship to the covariates (gradients) included (McCune and Mefford, 1999). Results can be reported in a biplot that allows simultaneous illustration of how sampling sites and species relate to covariates and which species are most associated with each site. Monte Carlo permutations will be used to test if the ordination was successful in explaining variance in assemblage structure. If the observed eigenvalues for axes are greater than 95% of eigenvalues from 1,000 randomized matrices (rows in the covariate matrix will be randomly reassigned, thus destroying the relationship between the species and covariate matrices), the ordination will be considered successful, and covariates will have been important in explaining variance in assemblage structure across sites.

2.5 REPORTS

During the project, there will three types of reports submitted to the OOC over the course of the 2-year project:

- Quarterly summary reports;
- First Year Data Report; and
- Final Report.



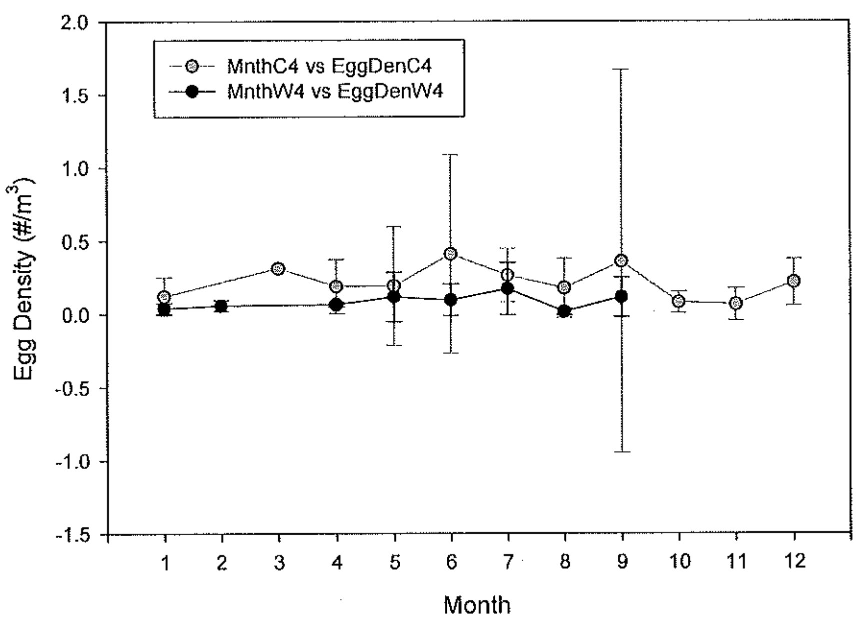


Figure 1. Average SEAMAP larval (top) and egg (bottom) with error bars (plus/minus stdev) for depth band 4 in W and C zones. Symbols indicate data points. Gaps of 1 month are filled in with a straight line. The larger gaps are left blank.

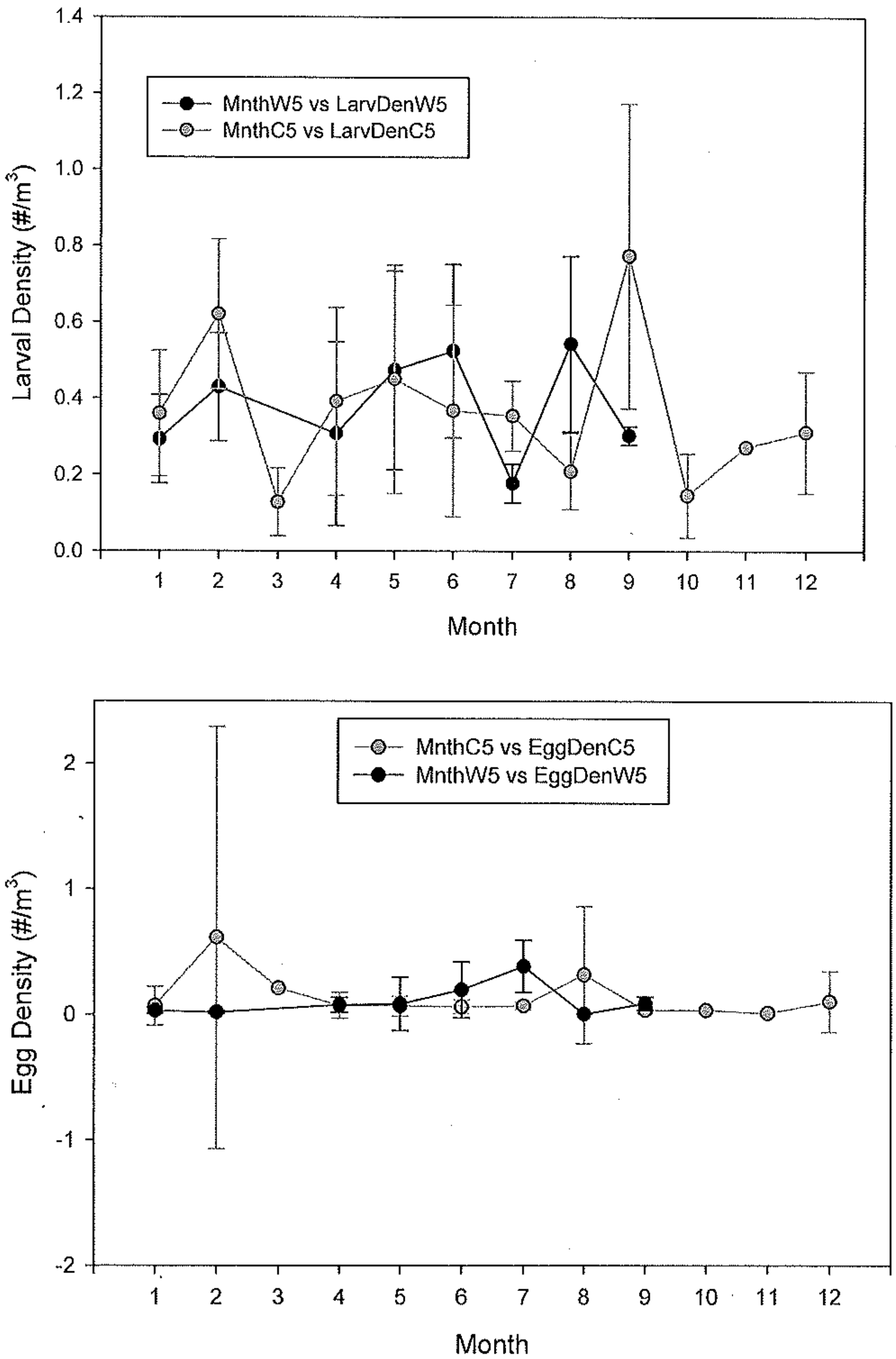


Figure 2. Average SEAMAP larval (top) and egg (bottom) with error bars (plus/minus stdev) for depth band 5 in W and C zones. Symbols indicate data points. Gaps of 1 month are filled in with a straight line. The larger gaps are left blank.